MDC Resource Science

Science Notes

Factors Influencing Neonicotinoid Insecticide Concentrations in Missouri Floodplain Wetlands

Missouri Department of Conservation (MDC)

2019 VOLUME 14 NO. 6

Factors Influencing Neonicotinoid Insecticide Concentrations in Missouri Floodplain Wetlands

By: Kyle Kuechle, (University of Missouri), Elisabeth B. Webb (USGS Missouri Cooperative Fish and Wildlife Research Unit), and Doreen Mengel (Missouri Department. of Conservation)

Background: Many floodplain wetlands in Missouri are subject to intensive management involving seasonal manipulation of water levels to ensure habitat availability timed with life history needs of wetland-dependent wildlife. Wetland management may also incorporate agricultural crop plantings to provide food for wildlife while resetting vegetative succession with associated soil disturbance. The introduction of insecticides (e.g., neonicotinoids) via agricultural seed treatments has created potential conflicting goals. We investigated the relationship between agricultural land use and neonicotinoid concentrations at publicly owned wetlands in Missouri. We focused on neonicotinoid detection frequency and concentrations in water and sediments from Missouri floodplain wetlands and factors influencing those concentrations. Our central hypothesis was that neonicotinoid concentrations would be positively associated with agricultural land use at various spatial scales (e.g., wetland to watershed).

Methods and Results: We selected 40 wetlands on 10 conservation areas (CA) managed by the Missouri Department of Conservation from which we collected water and sediment samples for neonicotinoid analysis during four sampling periods. We also collected a suite of wetland and landscape level variables that we hypothesized influenced neonicotinoid concentrations and evaluated these relationships using Boosted Regression Trees (BRTs). Analysis of 157 sediment samples resulted in detections of at least one neonicotinoid compound in 55% to 76% of the samples, depending on sampling period. Total detection frequency in sediments was greatest during spring 2016 (76%), and largely driven by clothianidin, which was detected in 55% of samples. Total mean sediment concentrations ranged from 0.71 µg/kg (i.e., ppb) in spring 2016 to 1.97 µg/kg in autumn 2016, with a maximum total neonicotinoid concentration of 17.99 µg/kg (autumn 2016). Analysis of 149 water samples resulted in detection of at least one neonicotinoid in 60% of all samples; however, concentrations were lower than predicted based on measured sediment concentrations and published organic carbon-water partitioning coefficients (K_{oc}). Mean total aqueous concentrations ranged from 0.003 to 0.11 µg/L, indicating potential for sediment bound neonicotinoids to desorb into the water column. To our knowledge, Missouri floodplain wetlands represent the first wetland system to exhibit neonicotinoid concentrations in sediment that are not in equilibrium with overlying water.

Through hierarchical BRT model selection, we found the amount of crop planted within a wetland (>25%), as well as the percentage of CA planted with treated seed (threshold of 25%), were positively associated with sediment neonicotinoid concentrations within a wetland (Figure 1A&B). Additionally, we found a negative relationship between water depths (>25cm) and neonicotinoid concentrations in wetland sediments (Figure 1C), as well as a negative, non-linear relationship with water temperature in which concentrations peaked between 15°C (59°F) and 20°C (68°F) (Figure 1D). It is likely that increased water depth combined with increasing temperatures (>68°F) creates conditions favorable for neonicotinoid degradation by promoting onset of anoxic conditions in sediments and increasing microbial activity that facilitates chemical breakdown. Further, greater water column depth can provide increased opportunity for photodegradation to occur. However, deeper water depth has also been shown to slow the breakdown of pesticides, including neonicotinoids. Therefore, it is likely that the negative relationship with water depth may have an upper limit at depths greater than measured in this study (72 cm), above which it begins to shield neonicotinoids from photolytic breakdown.

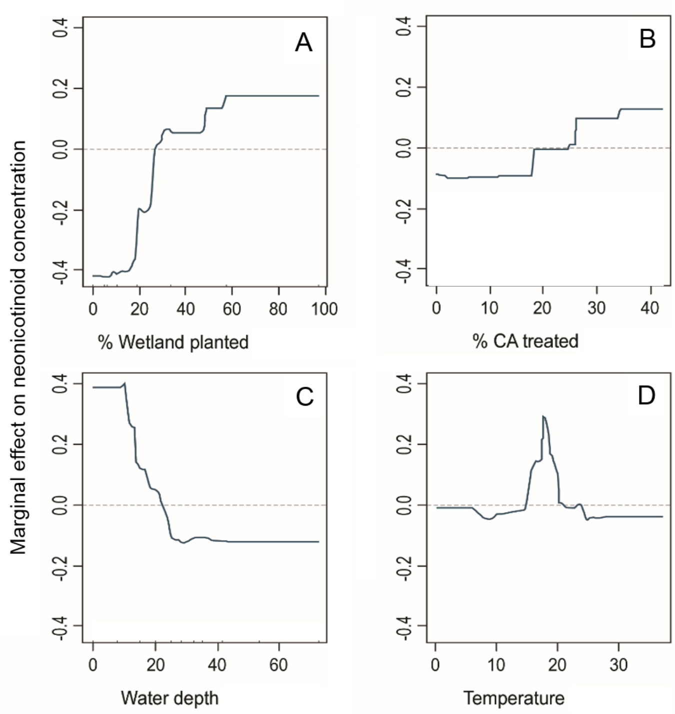

Figure 1. Partial dependency plots for: (A) % wetland planted, (B) % conservation area (CA) treated, (C) water depth (cm), and (D) temperature (°C). Plots represent variable effects on total sediment neonicotinoid concentrations.

Management Implications:
Sediment neonicotinoid concentrations were greater than predicted based on published K_{oc} values and measured water concentrations, indicating the sediment and water concentrations are not at equilibrium. The implications of this relationship are uncertain but it suggests that sediment concentrations may serve as a potential route of exposure to benthic invertebrates and a persistent source of neonicotinoids to the water column as they desorb and become more biologically available to aquatic organisms. Currently, uncertainty exists regarding toxicity implications of sediment concentrations found in this study as benchmarks have only been established for aqueous concentrations. However, efforts can be taken to mitigate sediment neonicotinoid concentrations including: 1) reduce amount of agriculture in both individual wetlands and CAs to <25% proportion planted with treated crop seed, 2) maintain water levels >25 cm in managed wetlands to prolong anoxic conditions during times with greater water temperatures (>68°F), thereby, promoting neonicotinoid degradation, and 3) avoid use of neonicotinoid-treated seed in areas subject to leaching or overland flow.

For more information, contact:
Missouri Department of Conservation
Resource Science Division
2901 West Truman Blvd.
Jefferson City, MO 65109
573-751-4115
research@mdc.mo.gov

Keywords: **neonicotinoids, agricultural land use, sediment concentrations, equilibrium, floodplain wetlands**